MULTI-CHANNEL SPATIAL POSITIONING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent claims the benefit of U.S. Provisional Patent Application 62/754,446, filed 1 Nov. 2018, titled "A MULTI-SENSOR SYSTEM FOR MONITORING CROWDS OF INDIVIDUALS." The entirety content of each aforementioned patent filing is hereby incorporated by reference.

BACKGROUND

1. Field

[0002] This disclosure relates generally to positioning systems and, more particularly, to multi-sensor positioning systems.

2. Background

[0003] Understanding visitor behavior is useful for the design, operation and optimization of public or semi-public spaces. Visitor behavior information is valuable to various stakeholders of the space, such as an owner of the space, an operator of the space, security personnel and merchant staff operating in the space, or the like.

[0004] Existing computer systems to determine indoor positions of visitors suffer from a number of challenges. Some systems require the visitor to wear a tracking device, but these arrangements are often untenable in public places, where people are unwilling to wear such devices. Some systems merely afford low-resolution, sparse indications of position, like card-based electronic door access controls.

SUMMARY

[0005] The following is a non-exhaustive listing of some aspects of the present techniques. These and other aspects are described in the following disclosure.

[0006] Some aspects include a process that includes acquiring, using a computer system, a set of images from a plurality of cameras, wherein: each of the plurality of cameras have a different respective field of view, and at least part of the fields of view are of a monitored environment; detecting and localizing, using the computer system, in at least some of the set of images, a first entity moving through the monitored environment; determining, using the computer system, a first set of locations within the monitored environment of the first entity based on locations of the first entity in the set of images, wherein each of the first set of locations is associated with an image acquisition time; acquiring, using the computer system, a set of sensor measurements of the monitored environment from a plurality of sensors, the plurality of sensors being different from the plurality of cameras; determining, using the computer system, a second set of locations within the monitored environment of the first entity based on the set of sensor measurements, wherein each of the second set of locations is associated with a sensor measurement time; determining, using the computer system, whether the first set of locations should be associated with the second set of locations based on a set of confidence factors calculated based on the first set of locations and the second set of locations, the set of confidence factors being indicative of the second set of locations being locations of the first entity and not another entity; in response to determining that the first set of locations should be associated with the second set of locations, determining, using the computer system, a sequence of locations of the first entity through the monitored environment; and storing, using the computer system, the sequence of locations in a computer-readable media in communication with the computer system.

[0007] Some aspects include a tangible, non-transitory, machine-readable medium storing instructions that when executed by a data processing apparatus cause the data processing apparatus to perform operations including the above-mentioned process.

[0008] Some aspects include a system, including: one or more processors; and memory storing instructions that when executed by the processors cause the processors to effectuate operations of the above-mentioned process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The above-mentioned aspects and other aspects of the present techniques will be better understood when the present application is read in view of the following figures in which like numbers indicate similar or identical elements:

[0010] FIG. **1** is a diagram of a monitored environment in which various entities may be tracked using the present techniques, in accordance with some embodiments;

[0011] FIG. **2** is a flowchart of operations to determine a sequence of locations based on a set of images and sensor measurements, in accordance with some embodiments;

[0012] FIG. **3** is a flowchart of operations to determine associations between devices and entities, in accordance with some embodiments; and

[0013] FIG. **4** shows an example of a computing device by which the present techniques may be implemented, in accordance with some embodiments.

[0014] While the present techniques are susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. The drawings may not be to scale. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the present techniques to the particular form disclosed, but to the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present techniques as defined by the appended claims.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0015] To mitigate the problems described herein, the inventors had to both invent solutions and, in some cases just as importantly, recognize problems overlooked (or not yet foreseen) by others in the field of indoor positioning. Indeed, the inventors wish to emphasize the difficulty of recognizing those problems that are nascent and will become much more apparent in the future should trends in industry continue as the inventors expect. Further, because multiple problems are addressed, it should be understood that some embodiments are problem-specific, and not all embodiments address every problem with traditional systems described herein or provide every benefit described herein. That said, improvements that solve various permutations of these problems are described below.